Energy

Studies and Coordination

Two types of energy consumption were analyzed for each build alternative: operational energy and construction energy. Operational energy consumption is defined as the energy used during operation of the proposed project; construction energy consumption is defined as the energy used during construction of the proposed project.

Operational energy consumption was analyzed using a method based on a U.S. Department of Transportation (USDOT) document, *Procedures for Estimating Highway User Costs, Fuel Consumption, and Air Pollution* (U.S. Department of Transportation 1980), along with personal communication with Peter Downey, Washington State Department of Transportation (WSDOT), March 1993. The driving speeds, delay, and vehicle miles traveled (VMT) were obtained from computer-simulated traffic model runs provided by the Spokane Regional Transportation Council (SRTC).

Construction energy consumption was analyzed by using fuel consumption rates per dollar of construction cost. These fuel consumption rates were based on the documents *Energy Analysis Handbook — Combining Process and Input Output Analysis* (University of Illinois 1976), and Highway Research Circular 158: *Fuel Usage Factors for Highway Construction* (Highway Research Board 1974). Construction cost estimates were provided by WSDOT and are based on a 23-year construction schedule.

Affected Environment

The primary sources of energy in the project area are hydrocarbons, including petroleum (primarily gasoline), natural gas, coal, and electricity. The 1990 vehicle energy consumed on the existing Spokane roadway network in the project area is estimated to be 1,192,131 giga joules (11,300 billion British Thermal Units [BTU]).

A BTU is defined as “the quantity of heat required to raise the temperature of one pound of water one degree Fahrenheit.” One gallon of gasoline is approximately equal to 132,000 kilojoules (125,000 BTUs).

Impacts

(For discussion of construction activity impacts, see the Construction Activity Impacts section of this EIS.)

Implementation of any of the “build” alternatives would reduce traffic congestion and increase average vehicle operating speeds in the Spokane area. This would result in lower average annual vehicle energy consumption rates. However, it should be noted that at speeds beyond approximately 60 kilometers per hour (km/h) or (40 mph), fuel consumption increases as speed increases.

Energy consumption estimates for operation of each of the “build” alternatives and the No-Build Alternative are shown in Table 4-18. The “build” alternatives include the operational energy from use of an I-90 C-D.

No-Build Alternative

The No-Build Alternative would consume more energy; thus, it would have greater impacts. As shown in Table 4-18, annual operational energy consumption would be higher under the No-Build Alternative than under any of the "build" alternatives in the design year 2020.

Energy Consumed Alternative	giga joules(billion BTU)
No-Build Alternative	24,431,928 (23,157)
Market/Greene Alternative with North Option	24,209,311 (22,946)
Market/Greene Alternative with South Option	24,221,972 (22,958)
Havana Alternative with North Option	24,292,661 (23,025)
Havana Alternative with South Option	24,268,395 (23,002)

Estimated Annual Energy Consumption During Operation of the North Spokane Freeway Project in Design Year 2020
Table 4-18

"Build" Alternatives

Energy consumption is lower for each build alternative than for the No-Build Alternative. The reduction in energy consumption associated with the "build" alternatives results from improved traffic flow and reduced congestion. Operation of the proposed project would not have a significant impact on energy sources, fuel availability, or production sources in the local area. Operation of any of the "build" alternatives could save between 3,997,395 and 6,389,775 liters (1,056,000 and 1,688,000 gallons) of gasoline annually.

Mitigation

No-Build Alternative

No mitigation would be required.

"Build" Alternatives

No mitigation measures would be required during operation of the proposed project, because operational impacts are less than those of the No-Build Alternative. However, incorporating high occupancy vehicle (HOV) lanes in the ultimate facility design will help decrease direct energy consumption by further improving traffic flow and reducing the use of single-occupant automobiles.

Geology and Soils

Studies and Coordination

Information on surface and subsurface conditions is from data collected by WSDOT, and from information published by the U.S. Geological Survey (USGS), the American Geological Institute, and the U.S. Department of Agriculture (USDA).

Topographical information was coordinated with agency officials from the USGS, WSDOT, and the USDA. Field investigations were conducted along each of the alignments and options.

Affected Environment

Over the course of several million years, the Spokane and other rivers carved a valley nearly 305 meters (1,000 feet) deep in what is now Spokane County. About one million years ago, approximately a third of the land area of the northern hemisphere was glaciated. At least four major episodes of large scale glaciation occurred, each providing very large volumes of gravel and sand. Ultimately, the Spokane Valley was refilled by glacial and glacio-fluvial material to its present elevation. Since the last glacial episode, the only significant erosion in the Spokane Valley was the formation of the present day 6 to 9 meter (20 to 30 foot) deep Spokane River channel.

The 150 to 180 meters (500 to 600 feet) of water-lain glacial detritus now form the Spokane aquifer, a deep, wide zone of highly porous, extremely permeable gravel and sand. The saturated part of that material, beginning from 15 to 150 meters (50 to 500 feet) below the surface, constitutes the aquifer. It is so permeable that the Spokane River is the only through-flowing stream on its surface and marks the upper surface of the water table. This permeability makes the aquifer exceptionally vulnerable to pollution from the surface (refer to Water Quality section of this chapter).

The project area is underlain by three major geologic units:

1. Metamorphic and igneous rocks more than 50 million years old
2. Basaltic lava flows 5 to 20 million years old
3. Silts, sands, and gravels that were deposited in their present form less than 50,000 years ago.

The oldest unit is mostly hard, tough metamorphic gneiss and granite rock that will require drilling and blasting for roadway placement. This rock is stable in cuts and highly resistant to weathering and erosion. It forms all outcrops above 760 meters (2500 feet), and local outcrops where exposed at lower elevations.

The younger bedrock unit is basalt. It was erupted as extensive lava flows and deposited on a surface that is now mostly covered by younger material. Therefore, its true distribution is known in only a very general way. It is not found above 760 meters (2500 feet) above sea level. Basalt, like the metamorphic rock it covers, is hard, tough, and highly resistant to weathering and erosion.

The third unit consists of unconsolidated, ice-transported, water lain, and windblown sediments that cover the irregular bedrock surface. The material is predominantly sand and gravel, porous and highly permeable. It is easily excavated and, because of its permeability, is generally well drained. However, saturation or near-saturation in late winter and spring make it susceptible to surface erosion, especially where particles are dominantly coarse (larger than one inch in at least one dimension).

Soils

There are five major soil groups present in the study area. The physical properties of each soil determine the engineering properties that must be considered in designing and constructing the project. All soils in the project area have a low shrink-swell potential, and most have relatively favorable shear strength and load-carrying capacity.

Table 4-19 shows the overall distribution of the various soil types and the soil percentages present along each alignment. Figures 4-5 through 4-7 show the distribution of the various soil types throughout the project area. More than 90 percent of the soils in the study area belong to the Garrison-Marble-Springdale classification. Soils associated with the Marble-Springdale Association (59 percent of the total project surface area) exhibit very high permeability (63.5 to 254 millimeters [2.5 to 10 inches] or more of water per hour). This greatly reduces their susceptibility to surface erosion. The Marble Association coarse sand loam (approximately 20 percent of the total project surface area) is highly susceptible to wind erosion.

Garrison gravelly loam (GgA) is found on 0 to 5 percent slopes. It is gravelly, medium-textured, somewhat excessively drained soil formed in gravelly glacial outwash material from a variety of acid igneous parent rock. The depth to a mixture of sand, gravel, and cobblestones ranges from 760 to 1520 millimeters (30 to 60 inches). The relevant engineering properties are slight to no frost action susceptibility, moderate to very high permeability, and low shrink-swell potential. The soil has a high shear strength and high load-carrying capacity.

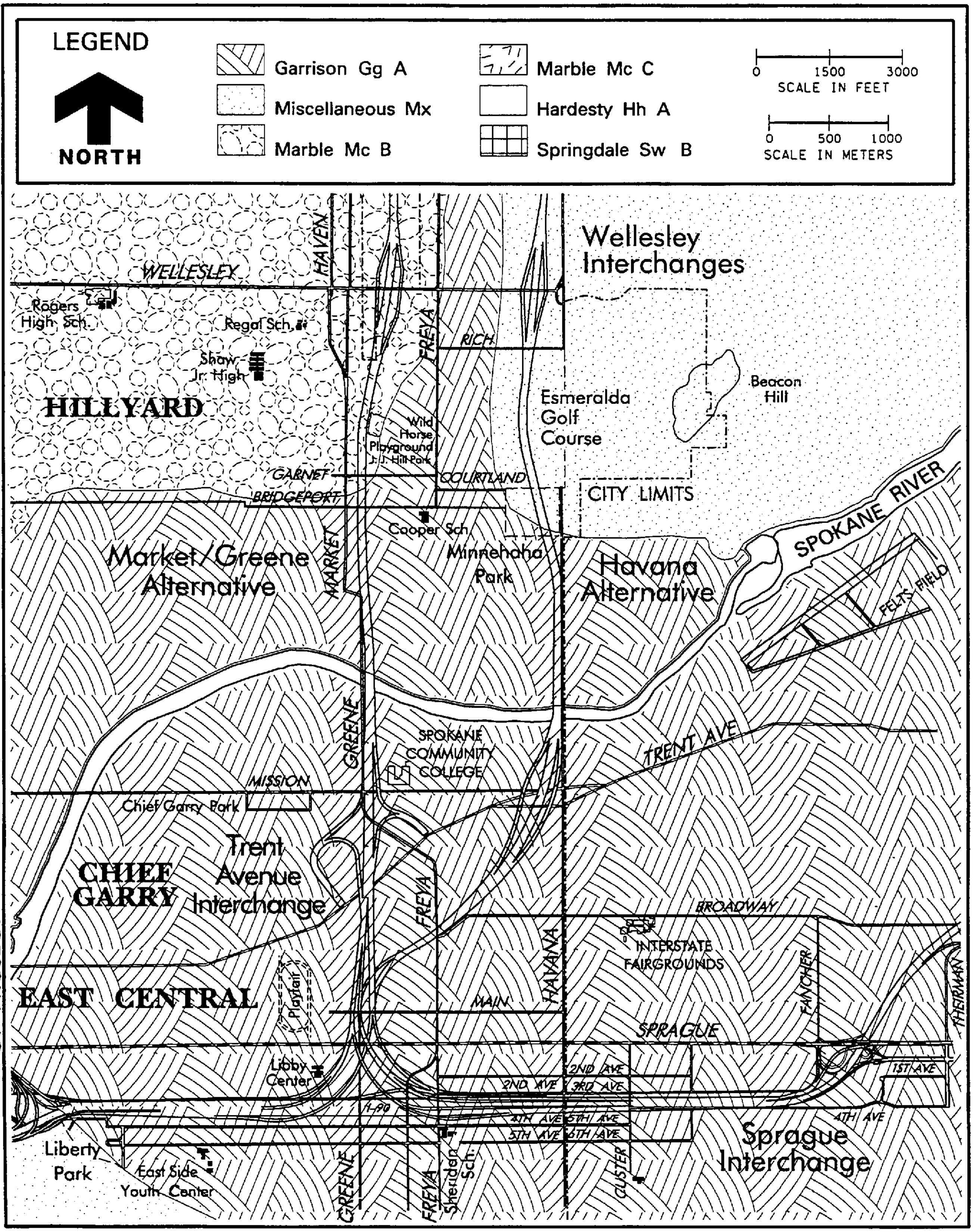
Marble sandy loam (McB) is also formed from sandy glacio-fluvial material. It is deep to moderately deep on 0 to 8 percent slopes. The texture is moderately coarse, underlain by thick beds of coarse sand. The soil has slight to no frost action susceptibility, moderately high to very high permeability, and low shrink-swell potential. Formations of McB have a high shear strength and high load-carrying capacity.

Soil Name	Soil Series	Map Symbol	Erosion Water	Potential Wind	Hydraulic Conductivity mm (inch) Water/Hour	Routes/Options[1] (Percentage of Area Underlain by soil type)			
						M/G	**H**	**N**	**S**
Garrison gravelly loam	Garrison	GgA	Slight		20.32-127(0.8-5)	50	40		
Marble sandy loam	Marble	McB	None		63.5->254(2.5->10)	50	5		10
Marble loamy course sand	Marble	MbC	Slight	Severe	127->254(5->10)		5	80	45
Springdale gravelly sandy loam	Springdale	SwB	Slight		127->254 (5->10)			10	30
Hardesty silt loam	Hardesty	HhA	None		20.32-254(0.8-10)		25	5	10
Miscellaneous[2]	Various	Mx					25	5	5
						TOTALs			
						100	100	100	100

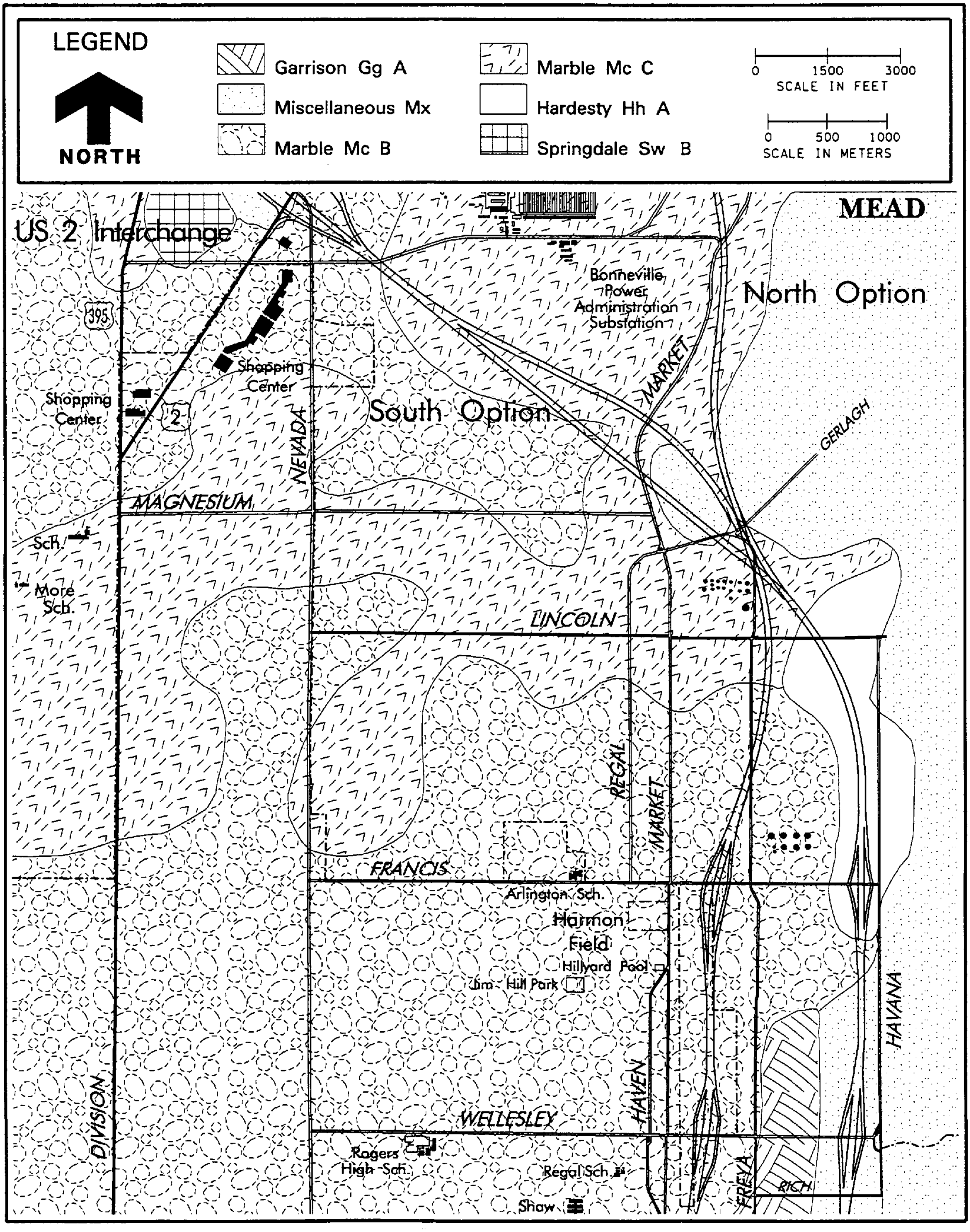
NOTES:
1. M/G = Market/Greene Alternative; H = Havana Alternative; N = North Option; and S = South Option
2. Includes Narcisse and Spokane Association soils.

Physical Properties of Soil Types
Table 4-19

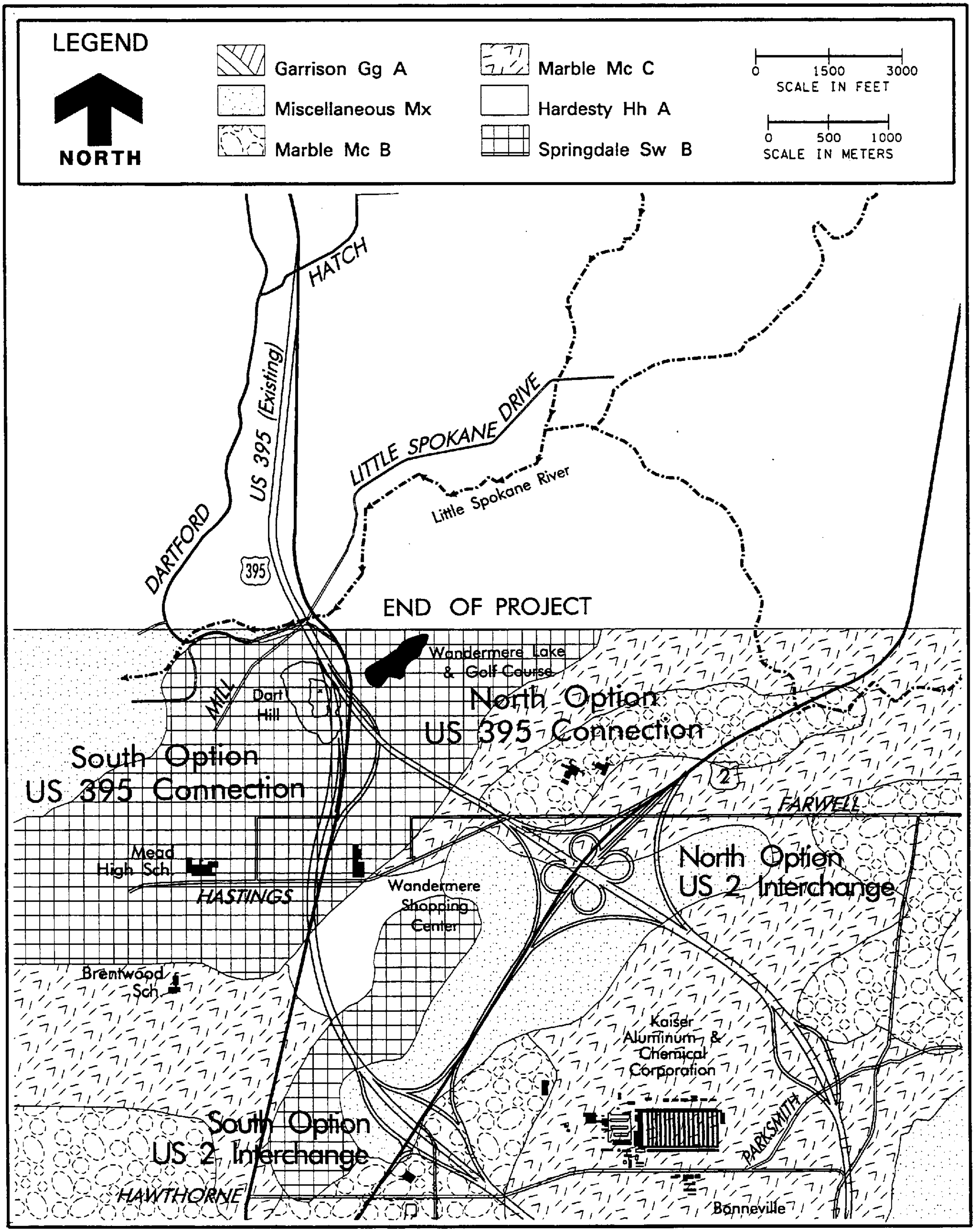
Marble loamy coarse sand (MbC) is formed from wind-worked sandy glacio-fluvial material on gently sloping to rolling dune-like topography. It is found on 0 to 30 percent slopes. The formation may be very deep. The soil has slight to no frost action susceptibility, moderately high to very high permeability, and low shrink-swell potential. Formations of MbC have a high shear strength and load-carrying capacity.



Market/Greene (Preferred Alternative) and Havana Alternative
Geology and Soils — Area 1
Figure 4-5



Market/Greene (Preferred Alternative) and Havana Alternative
Geology and Soils — Area 2
Figure 4-6



North Option (Preferred Alternative) and South Option Geology and Soils — Area 3
Figure 4-7

Springdale gravelly sandy loam (SwB) developed from glacial outwash of acidic igneous origin. It is found on 0 to 20 percent slopes and is moderately coarse in texture. The relevant engineering properties are slight frost action susceptibility, high to very high permeability, and low shrink-swell potential. This soil also has a high shear strength and high load-carrying capacity.

Hardesty silt loam (HhA) is formed on 0 to 5 percent slopes. It is very deep, moderately well drained, medium textured soil formed from volcanic ash. HhA is commonly found in small bodies at the toe of terrace breaks or rock ledges. The relevant engineering properties include moderate to very high susceptibility to frost action, moderate to high permeability, and low shrink-swell potential. This soil has very low shear strength and moderate load-carrying capacity.

Topography

The topography of the project area is shown in the topographic contours of Figures 4-5 through 4-7. Most of the area, underlain by unconsolidated sediments, is flat to gently rolling, with gentle slopes, except where steepened by relatively recent stream erosion. Sand dunes 6 to 15 meters (20 to 50 feet) high are local features in parts of the project area north of Lincoln Road. Slopes are steeper near the Little Spokane River to the north. Where the stream has cut through the unconsolidated sediments to bedrock, slopes are generally steeper than 45 degrees and can approach vertical at some locations.

The Spokane and Little Spokane Rivers are the only permanent waterways in the study area. The generally high permeability of the Pleistocene sediment results in absorption of essentially all surface precipitation under most weather conditions and with natural ground cover, eliminating surface runoff as a source for other streams.

The city of Spokane is located on top of a basaltic outcrop and glacio-fluvial outwash. Remnants of the Selkirk Mountain Range are visible from the city.

The drainage pattern exhibited by the Spokane and Little Spokane Rivers is typical of young land forms having flat or undulating topographic surfaces and high water tables. They typically contain marshes, ponds, or small streams.

The drainage texture for the study area can be classified as coarse, characterized by parent rock that is more resistant (granites, gneiss, and schists). It weathers to form coarse, permeable soils.

Elevations from south to north range from 534 meters (1,915 feet) along the I-90 Collector/Distributor to a high of 626 meters (2,055 feet) along the Havana Alternative at Beacon Hill and a low of 566 meters (1,725 feet) at the northwest edge of the project area near the crossing of the Little Spokane River. Elevations along the mountainous area next to the Havana Alternative start at 610 meters (2,000 feet) and rise steeply to about 750 meters (2,400 feet) at Beacon Hill.

Regional Faults/Seismicity

There has been no damaging earthquake in Spokane since historical record-keeping began (around 1840), and there is no evidence of earthquakes in local geologic structures.

Due to the absence of geologic structures such as active faults or volcanoes (in the past 12,000 years), or tectonic plate boundaries, there is no calculable potential for a damaging earthquake in the area.

There are no known ancient landslide areas or other geological hazards that would impact this project. The project area appears to be geologically stable.

Ground Water

The Spokane aquifer is replenished by recharge through:

- Intermittent streams and ground water inflow from the boundaries
- Surface precipitation
- Percolation of pumped ground water through irrigation
- Percolation from septic tank drain fluids

Discharge in the aquifer occurs through:

- Leakage to the Spokane River and the Little Spokane River
- Pumping from wells
- Evapotranspiration
- Ground water outflow

The Spokane aquifer underlies the Spokane Valley. It occupies an area about 48 kilometers (30 miles) long and between 4.8 and 13 kilometers (3 and 8 miles) wide. The total area is about 350 square kilometers (135 square miles). It is unconfined, meaning its upper boundary extends to the earth's surface. The direction of ground water movement in the study area is north-northwest in the area immediately north of the Spokane River, and west-northwest approaching north of the project terminus at the Little Spokane River.

The Spokane aquifer is one of the most efficient in the United Sates. Since it is composed primarily of sand and gravel and is highly permeable, the rate of water movement through the reservoir is high, with rapid lateral movement throughout. Seasonal water fluctuations throughout the reservoir are less than 3 meters (10 feet); in the study area, the water table fluctuates by only .6 to 1.5 meters (2 to 5 feet). The depth to the aquifer in the study area ranges from 9 to 12 meters (30 to 40 feet) at the I-90 interchange, gradually increasing to 55 meters (180 feet) at Francis Avenue. The aquifer is at the surface in the vicinity of Wandermere Lake (east of US 395) near the far northeast edge of the project area.

Surface Drainage

Market/Greene Alternative (Preferred Alternative)

Soils along this route are split equally between Garrison gravelly loam (south half) and Marble sandy loam (north half). When water enters the soil system, it infiltrates rapidly. There is little or no erosion hazard associated with these soils.

Market/Greene (Preferred Alternative) — North Option (Preferred Alternative)

Although a large percentage of the soil types along this route tend to collect water on the surface, once the water has entered the drainage system it infiltrates quickly.

Inundation is possible in Peone silt loam soil in the area of Market at Magnesium from February through May. There is little or no water erosion hazard associated with these soils.

Market/Greene — South Option

For most of the soils present, water entering the drainage system infiltrates rapidly. The soil at Pine Acres Golf Course (Hardesty silt loam) is usually wet from December through April. There is no water erosion hazard associated with these soils.

Havana Alternative

- Wellesley at Havana (Narcisse and Spokane Association silt loams) — Surface water drains slowly. Infiltration is usually somewhat slow, causing the soil to be wet from February through May.
- Francis at Havana (Peone silt loam) — Since surface water drains slowly, water tends to collect at the surface for long periods of time. Once water is in the soil, the poor hydraulic conductivity tends to keep the soil saturated a large part of the time. This results in local inundation from February through May.
- Houghton at Havana (Hardesty silt loam) — Surface water drains slowly and water has a tendency to collect on the surface for long periods of time. Once in the soil, the water moves slowly. This soil is usually wet from December through April.

Havana — North Option

See Market/Greene — North Option.

Havana — South Option

See Market/Greene — South Option.

I-90 Collector/Distributor (C/D) System (part of the Preferred Alternative)

The soils along the I-90C/D system are well drained and have minimal potential for erosion.

Impacts

No-Build Alternative

(For discussion of construction activity impacts, see the Construction Activity Impacts section of this EIS.)

The No-Build Alternative would not alter or cause impacts on the existing conditions in the project area.

Build Alternatives

Topography will be altered through cut and fill slopes, embankment material, excavation, disposal of waste materials, retaining walls, ditching, and trenching.

No impacts are expected from operation of the proposed project due to erosion (wind or water) or altered topography (includes natural drainage channels). Rivers, streams, creeks, wetlands, etc. will be avoided or spanned by bridge structures.

Steps will also be taken to prevent long-term erosion (wind or water) on any embankment, roadway shoulder, drainage channel segment, or graded section as part of the proposed project by use of Best Management Practices (BMPs), within their design parameters. These areas will be reviewed and revegetated, as needed, with erosion control grass mixtures, or protected by other sediment control measures such as, but not limited to, wind/water erosion control mat (natural or synthetic) material, additional plants and bushes where warranted, and proper maintenance of other permanent BMPs. A Storm Water Site Plan will be developed for both temporary and permanent measures using BMPs. The site plan will also address the requirements of the National Pollution Discharge Elimination System (NPDES).

Mitigation

No mitigation is proposed.

Waterways and Hydrological Systems

Studies and Coordination

Information for this report was obtained from the U.S. Geological Survey (USGS), the Washington State Department of Ecology (ECOLOGY), the city of Spokane Planning and Programming Office, and the Engineering Division of the Spokane County Public Works Department. The following references were also used:

- USGS Topographical Maps
- *Groundwater,* R. Allan Freeze and John A. Cherry
- *The Spokane Aquifer, Washington: Its Geologic Origin and Water-Bearing and Water-Quality Characteristics,* Dee Molenaar, USGS
- Communications with the Corps of Engineers (Refer to the Public and Agency Coordination Section of this EIS.)

The EPA is a cooperating agency, but has directed WSDOT to confer with Spokane County on matters related to the Spokane Sole Source Aquifer. The Spokane County Stormwater Aquifer protection requirements will be followed. This program has been approved by Ecology and the E.P.A.

The route alternative sites were inspected to determine possible additional hydraulic and hydrologic impacts. The infiltration capacity of the soils was also analyzed, to assess the potential impact of high storm water runoff rates during a design storm with a 10-year recurrence interval (see Table 4-20).

A Hydraulic Project Approval (HPA) permit will be obtained from the Department of Fish and Wildlife (WDFW), a Shoreline Permit from the city of Spokane and/or the county, Nationwide 404 permit numbers 13 and 15 from the Corps of Engineers, and a Flood Plain Development Review will be conducted by Spokane County prior to each final North Spokane Freeway (NSF) phase project approval (when required).

Affected Environment

Sole Source Aquifer

The Spokane Aquifer and the Spokane River are the primary hydrologic features in the study area. They both have been shown to exchange water continuously from